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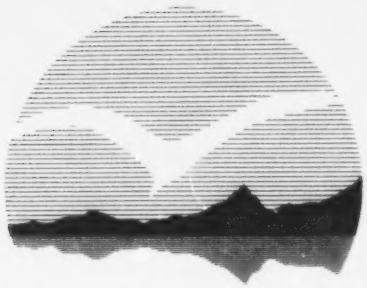

WATER RESOURCES BRANCH

SASKATCHEWAN DISTRICT

INFLOW/OUTFLOW MODEL FOR NET DEPLETION OF THE VAL MARIE AREA

INFLOW/OUTFLOW MODEL
FOR
NET DEPLETION
OF THE
VAL MARIE AREA

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GLOSSARY

AES	Atmospheric Environment Service Environment Canada
CD ROM	Compact Disk Read Only Memory (optical disk)
PFRA	Prairie Farm Rehabilitation Administration
USGS	United States Geological Survey
WRB	Water Resources Branch Environment Canada

SUMMARY

This report is an examination of a proposed inflow/outflow technique for determining net depletion of the Val Marie portion of the Frenchman River basin.

Historical records for Val Marie area provide only four years of useable irrigation season records, 1966, 1968, 1969 and 1988.

The inflow/outflow model yielded results generally not in agreement with accepted results for 1966, 1968 and 1969. In 1988 the model gave nearly the same results as the conventional technique.

Disagreement between model and conventional results occur during periods with substantial rainfall or large irrigation diversion. It is not clear whether this disagreement is a result of error in estimating local inflow or error in estimating irrigation return flow.

The uncertainty of model results is due exclusively to estimating local inflow from the ungauged portion of the Val Marie area (422 km^2). The uncertainty of conventional results is due to estimating irrigation return flow and the cumulative errors of the many stations used.

Data collection and testing of the model should continue.

INFLOW/OUTFLOW MODEL FOR NET DEPLETION OF VAL MARIE AREA

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1.0 INTRODUCTION

In Saskatchewan, Canada, the Val Marie portion of the Frenchman River basin contains two reservoirs (Huff Lake and Newton Lake), five irrigation canals and two significant tributaries (Denniel Creek and Denniel Creek East Tributary). Since the Frenchman River is an international stream, a close tally of water usage must be kept for the purpose of determining natural flow at the international boundary and resulting apportionment of flow. At present in the Val Marie area a complex system of flow, level, gate and pump stations is used to determine net depletion of the Frenchman River in the area.

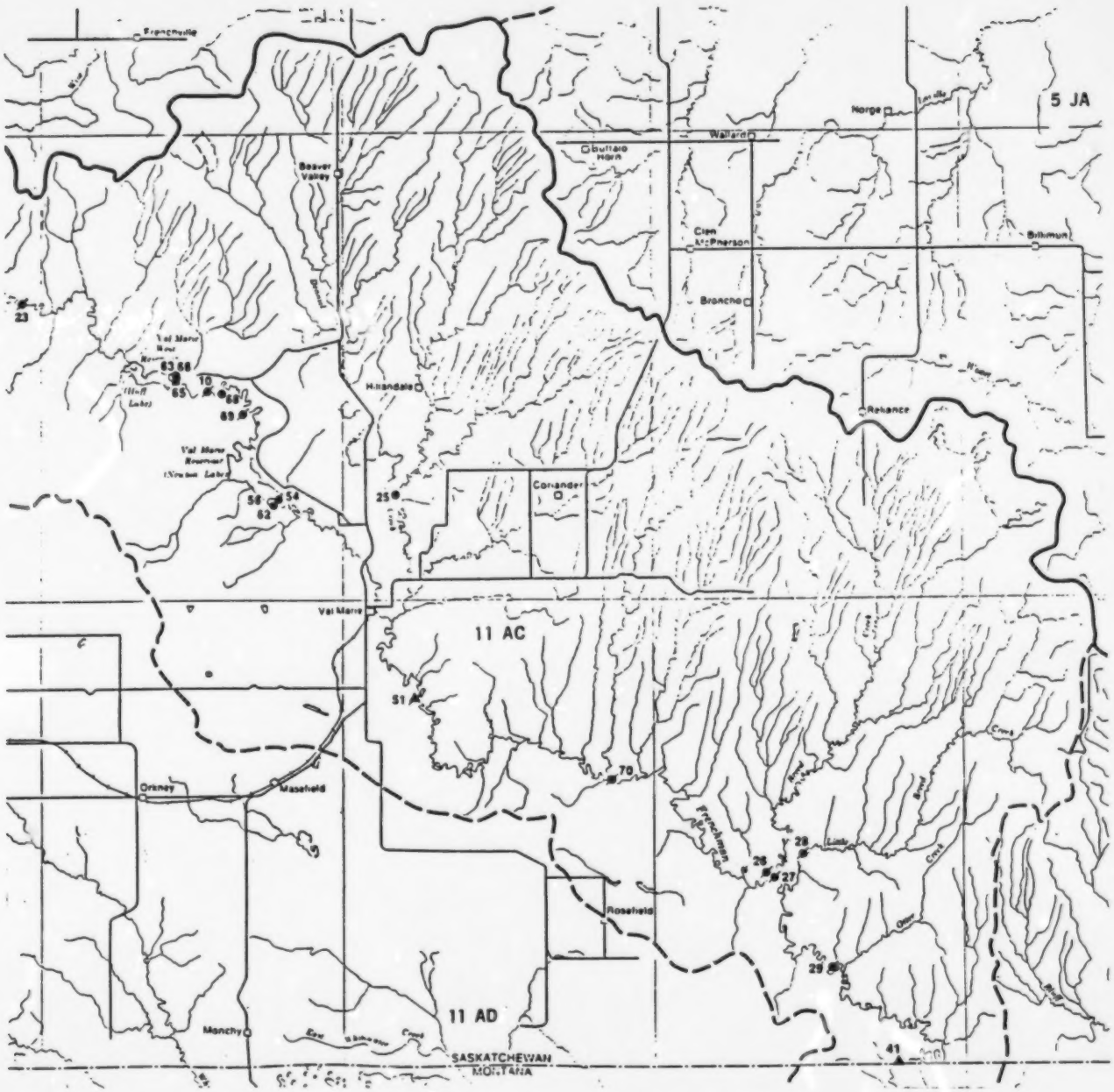
The technical staff of Water Resources Branch, Saskatchewan have proposed an inflow/outflow system of stations for the Val Marie area (see Figures 1, 2 and 3). It is hoped the proposed system will simplify and increase the accuracy of net depletion calculations.

This report will examine the procedure and accuracy of net depletion calculations using the proposed system of stations.

FIGURE 1

VAL MARIE AREA

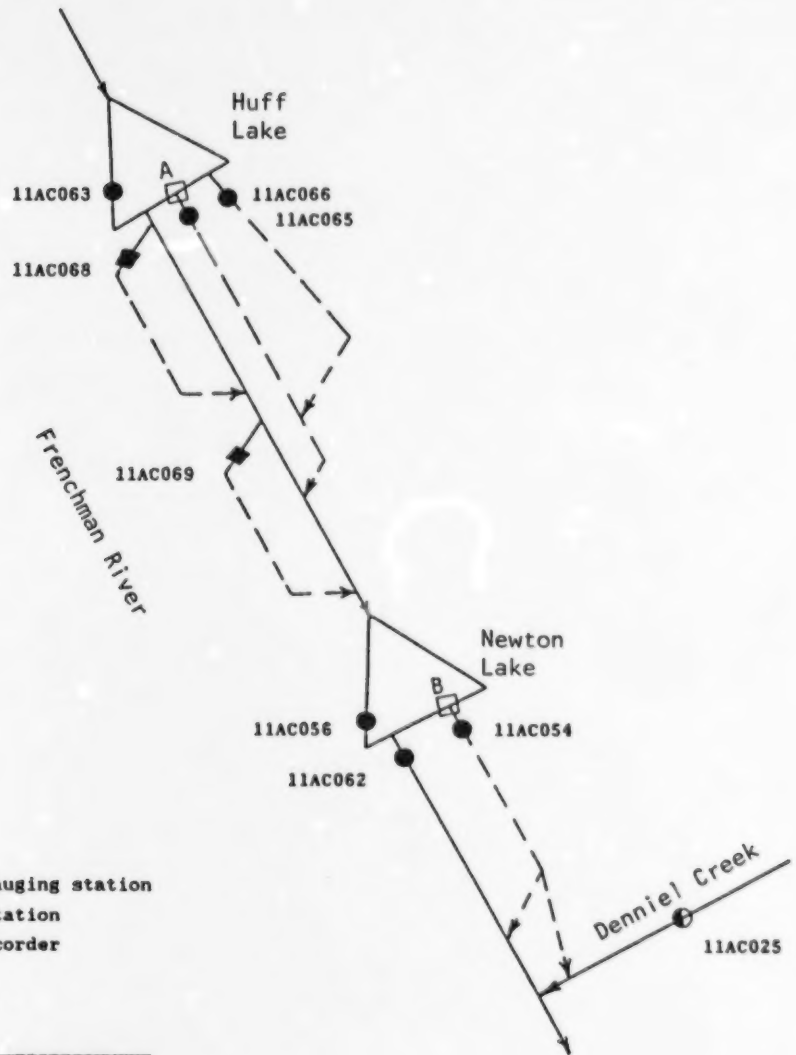
(From Eastern Tributaries of The Milk River 1987)



11AC023 Frenchman River at 50 Mile
11AC025 Denniel Creek
11AC041 Frenchman River at International Boundary
11AC051 Frenchman River below Val Marie
11AC054 Newton Lake Main Canal
11AC056 Newton Lake
11AC062 Frenchman River below Newton Lake
11AC063 Huff Lake
11AC065 Huff Lake Gravity Canal
11AC066 Huff Lake Pumping Canal
11AC068 Val Marie Pump No. 1
11AC069 Val Marie Pump No. 2
11AC073 Denniel Creek East Tributary (not shown)

FIGURE 2

SCHEMATIC MAP
FRENCHMAN RIVER VAL MARIE AREA
Present Network



● International gauging station
◐ Other gauging station
□ Gate opening recorder
– – – Return Flow
◆ Minor Diversion

STATIONS REQUIRED FOR APPORTIONMENT

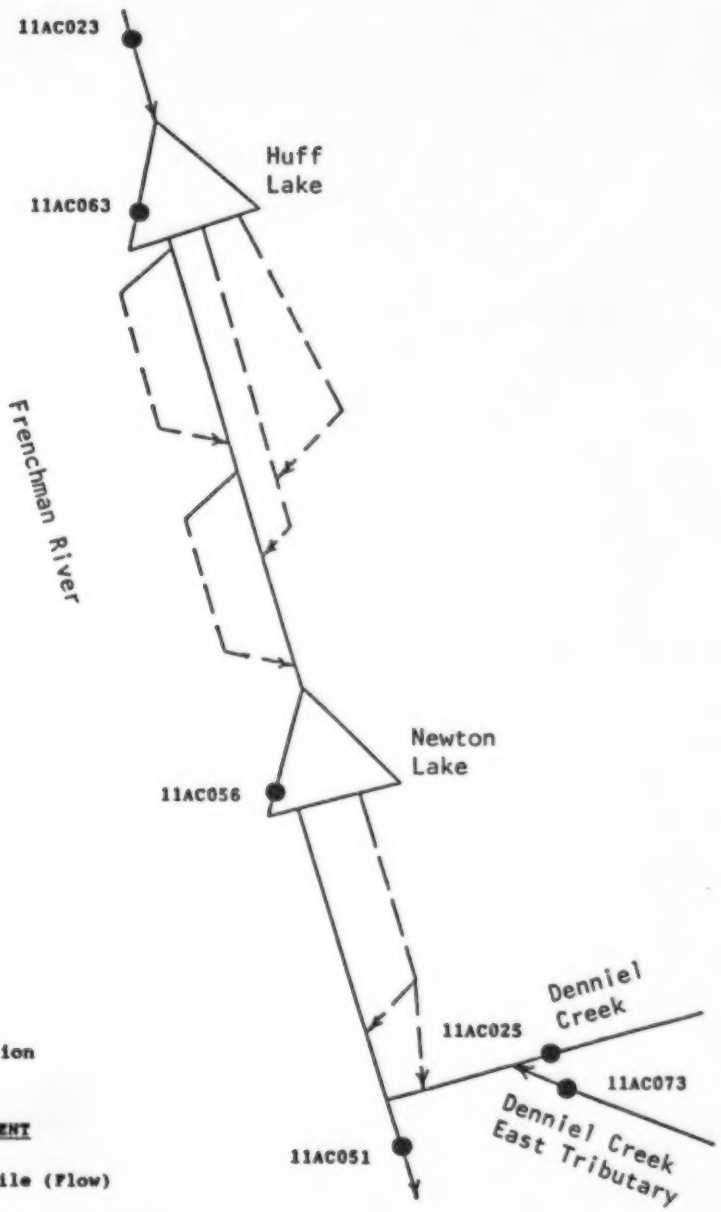
11AC054 Newton Lake Main Canal (Level)
11AC056 Newton Lake (Level)
11AC063 Huff Lake (Level)
11AC065 Huff Lake Gravity Canal (Level)
11AC066 Huff Lake Pumping Canal (Diesel pumps)
11AC068 Val Marie Pump No. 1 (H-flume)
11AC069 Val Marie Pump No. 2 (Electric pump)
A Gate openings for Huff Lake Gravity Canal
B Gate opening for Newton Lake Main Canal

STATIONS NOT REQUIRED FOR APPORTIONMENT

11AC025 Denniel Creek (Flow)
11AC062 Frenchman River below Newton Lake (Flow)

FIGURE 3

SCHEMATIC MAP
FRENCHMAN RIVER VAL MARIE AREA
Proposed Network



● International gauging station

STATIONS REQUIRED FOR APPORTIONMENT

11AC023 Frenchman River at 50 Mile (Flow)
11AC025 Denniel Creek (Flow)
11AC051 Frenchman River below Val Marie (Flow)
11AC073 Denniel Creek East Tributary (Flow)

STATIONS NOT REQUIRED FOR APPORTIONMENT
(Month-end Contents Only)

11AC056 Newton Lake (Level)
11AC063 Huff Lake (Level)

1.1 INFLOW/OUTFLOW MODEL

1.1.1 Derivation of net depletion algorithm

An inflow/outflow system has been proposed for calculating net depletion of Frenchman River in the Val Marie area (Yee, 1986). The proposed system treats the entire area as a "blackbox". If all flow into the box and all flow out of the box is known, then the difference must be net depletion (what is used in the box), regardless of the complexities within the box.

The following is a summary of inflow and outflow for the Val Marie area.

Major sources of inflow, which make up the significant portion of inflow, are: Frenchman River,
Denniel Creek,
Denniel Creek East Tributary,
local inflow.

Minor sources of inflow are: natural springs,
irrigation from local groundwater.

Major sources of outflow are: irrigation,
reservoir evaporation,
channel loss (Johnson, 1986),
Frenchman River.

Reservoir releases and storage occur inside the box so they are not considered inflow and outflow, however they will register in calculations of net depletion. Inflow and outflow for the system are shown schematically in Figure 4.

Net depletion is defined as subtractions or additions to the natural flow of a stream. Using the schematic the following model algorithm is developed:

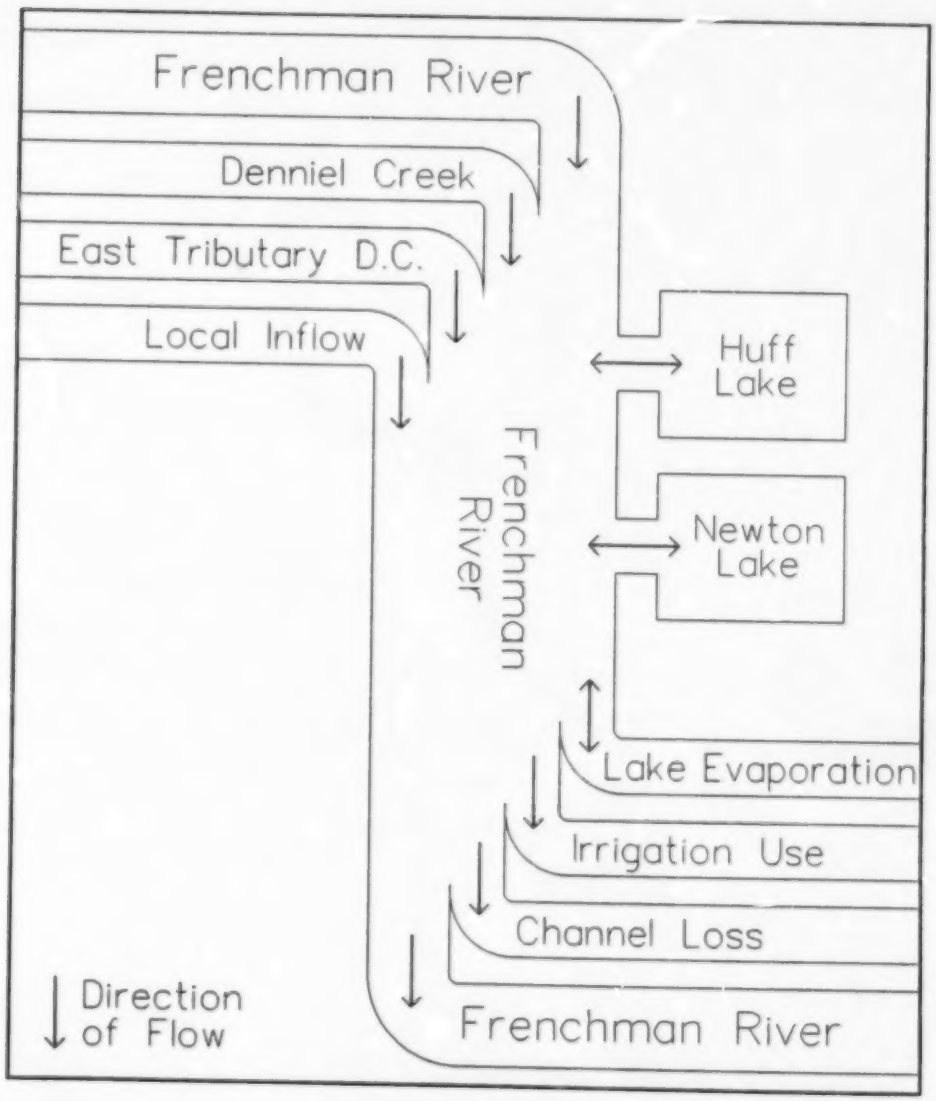
Sum of Inflows	- Natural Loss	- Net Depletion	= Flow of Frenchman River (leaving box)

By rearranging the model algorithm net depletion can be shown as:

Net Depletion	= Sum of Inflows	- Natural Loss	- Flow of Frenchman River (leaving box)

In the model the sum of inflows are the flows of: the Frenchman River (entering box), Denniel Creek, Denniel Creek East Tributary and local inflow. Natural loss is the channel loss from the

FIGURE 4
INFLOW/OUTFLOW DIAGRAM
Val Marie Area



inflow volume of the Frenchman River as the stream flows through the Val Marie area. Net depletion determined by the model represents: irrigation use, reservoir evaporation and reservoir storage or release.

1.1.2 Examination of historical records

Data points and useable data are limited to that which can be found in the historical records for the Val Marie area. The following stations have overlapping years of record and are reasonably located for the purposes of this study.

11AC023 Frenchman River at 50 Mile : Flow

11AC025 Denniel Creek near Val Marie : Flow

11AC051 Frenchman River below Val Marie : Flow

These three stations were equipped with automatic recorders and simultaneously operational for the years 1964 to 1969 and 1988 (Inland Waters Directorate, 1989, p.313-314). Of these years complete records for the irrigation periods, May to August, are found only in the years 1966, 1968, 1969 and 1988 with some estimation required for three days in April, 1969 at 11AC023 and for twenty days in April and May, 1966 at 11AC025. In 1988 a flow station, 11AC073 Denniel Creek East Tributary, was installed. The flows for Denniel Creek East Tributary must be estimated for years prior to 1988.

1.1.3 Apportionment periods

Apportionment periods for the model are chosen to match the established ten day periods for international apportionment of the Frenchman River. This aids in comparing model results with conventional results.

The model periods are based on a two day lag from 11AC023 (Frenchman River at 50 Mile) to 11AC051 (Frenchman River below Val Marie), a one day lag from 11AC025 and 11AC073 (Denniel Creek and Denniel Creek East Tributary) to 11AC051 (Frenchman River below Val Marie) and a two day lag from 11AC051 (Frenchman River Below Val Marie) to 11AC041 (Frenchman River at International Boundary). Time lags and chosen model periods were derived from examination of established periods (USGS and WRB, 1981, p.6.3), river reach lengths (Martin, 1987) and historical peaks (Environment Canada, 1988). Table 1 is a list of station periods chosen to give results at the international boundary.

TABLE 1

MODEL PERIODS

Period 11AC023 Frenchman River at 50 Mile	Period 11AC025 11AC073 Denniel Creek and East Trib.	Period 11AC051 Frenchman River below Val Marie	Period 11AC041 Frenchman River at Int. Bound.
Apr 27-May 6	Apr 28-May 7	Apr 29-May 8	May 1-10
May 7-16	May 8-17	May 9-18	May 11-20
May 17-27	May 18-28	May 19-29	May 21-31
May 28-Jun 6	May 29-Jun 7	May 30-Jun 8	Jun 1-10
Jun 7-16	Jun 8-17	Jun 9-18	Jun 11-20
Jun 17-26	Jun 18-27	Jun 19-28	Jun 21-30
Jun 27-Jul 6	Jun 28-Jul 7	Jun 29-Jul 8	Jul 1-10
Jul 7-16	Jul 8-17	Jul 9-18	Jul 11-20
Jul 17-27	Jul 18-28	Jul 19-29	Jul 21-31
Jul 28-Aug 6	Jul 29-Aug 7	Jul 30-Aug 8	Aug 1-10
Aug 7-16	Aug 8-17	Aug 9-18	Aug 11-20
Aug 17-27	Aug 18-28	Aug 19-29	Aug 21-31

1.1.4 Inflow Calculations

The records for the above mentioned stations are average daily flows in cubic metres per second (m^3/s). For apportionment procedures the chosen unit of measure is cubic decametres (dam^3) per 10 or 11 day period. In this model the average daily flows for a period are summed and multiplied by a constant factor, 86.4 $s/day*m^3/dam^3$ to yield cubic decametres per period. Inflow volumes for the Frenchman River, Denniel Creek, Denniel Creek East Tributary and outflow volumes for the Frenchman River were calculated using this method.

1.1.5 Estimated inflows

As mentioned earlier, flows for Frenchman River at 50 Mile and Denniel Creek required some estimation for missing days of record. The estimated flows are shown in Appendix 4 and are based on examination of spring flow patterns. Estimation of local inflow and flows for 1966, 1968 and 1969 at 11AC073 (Denniel Creek East Tributary) are based on the ratios of effective drainage areas and inflow at 11AC025 (Denniel Creek) since the Denniel Creek basin is in a near natural state.

TABLE 2

EFFECTIVE DRAINAGE AREAS
(from Meid and Schoenfield, 1989, p.56)

Station	Name	Area km^2
11AC023	Frenchman River at 50 Mile	2 670
11AC025	Denniel Creek	475
11AC051	Frenchman River below Val Marie	3 685
11AC073	Denniel Creek East Tributary	118

The effective drainage area of the ungauged portion of the Val Marie area has been determined using the following equation.

ungauged area = 11AC051 - (11AC023 + 11AC025 + 11AC073) areas
= 3 685 - (2 670 + 475 + 118) km^2
= 422 km^2

Local inflow is taken as a ratio of inflow at 11AC025 (Denniel Creek). The ratio is derived from effective drainage areas of Denniel Creek and the ungauged portion of the Val Marie area. Local inflows are estimated as volumes per period.

BASIN RATIO AND INFLOW EQUATION FOR UNGAUGED VAL MARIE AREA

ungauged area/11AC025 area = 422 km^2/475 km^2 = 0.888

Local inflow = 0.888*inflow at 11AC025

Estimation of daily inflow from Denniel Creek East Tributary for 1966, 1968 and 1969 is done in a similar fashion. The estimated daily flows are converted to period volumes using the procedure described in section 1.1.4

BASIN RATIO AND INFLOW EQUATION FOR EAST TRIBUTARY

11AC073 area/11AC025 area = 118 km^2/475 km^2 = 0.248

East Tributary inflow = 0.248*inflow at 11AC025 - 0.006 m^3/s

Examination of preliminary data for 1989 shows a flow of 0.025 m^3/s is recorded in Denniel Creek when a trickle flow is recorded in the East Tributary, so a minimum cutoff constant of 0.248*0.025 m^3/s=0.006 m^3/s is used when estimating daily flow in

the East Tributary. When subtraction of the minimum constant gives a negative result the value is taken as zero. Zero flow was recorded in the East Tributary in 1988.

1.1.6 Channel losses

Calculation of channel loss through the box and to the international boundary is done using the following equation from WRB Procedures Manual (USGS and WRB, 1981, p.6.15).

$$\text{channel loss} = [K*\text{Days} + P*(|Q| - K*\text{Days})]*Q/|Q|$$

For channel loss through the box the constant loss factor (K) for channel loss from Frenchman River below Val Marie to the International Boundary (Collier, 1960 p.8) is multiplied by the ratio of river reach lengths ie: 11AC023 (Frenchman River at 50 Mile) to 11AC051 (Frenchman River below Val Marie) divided by 11AC051 (Frenchman River below Val Marie) to 11AC041 (Frenchman River at International Boundary).

11AC023 to 11AC051 divided by 11AC051 to 11AC041
(Martin, F.R.J., 1985)

71.6 km/96.7 km = 0.740

K for reach 11AC051 to 11AC041
(USGS and WRB, 1981, p.6.16)

4.92 dam^3/day

K for reach 11AC023 to 11AC051

0.740*4.92 dam^3/day = 3.64 dam^3/day

The variable loss factor (P) is more a function of region than river reach distance (Cuthbert and Langley, 1974, p.30) so values of P for channel loss through the box are the same as those for Frenchman River below Val Marie to the International Boundary (USGS and WRB, 1981, p.6.16).

TABLE 3

VALUES OF P

April 28-May 28	0.10
May 29-Aug 28	0.16
Aug 29-Sep 27	0.10

For channel loss through the box, gross volume (Q) is inflow volume for Frenchman River at 50 Mile since expected flow at Frenchman River below Val Marie is the desired result. For channel loss from Frenchman River below Val Marie to the International Boundary, Q is net depletion since the effect of net depletion at the International Boundary is the desired result.

1.1.7 Spreadsheets

The model is designed to determine net depletion of Val Marie area at the International Boundary. Tests of the model are done with SQLCALC spreadsheet software. Two different spreadsheets are used, S1 and S2. S1 is used to input daily flows in an irrigation season and output volumes per chosen 10 day periods (see Appendix 1). S2 uses output from S1 and calculates net depletion for the Val Marie area. S2 estimates local inflow and channel losses for reach 11AC023 (Frenchman River at 50 Mile) to 11AC051 (Frenchman River below Val Marie) and reach 11AC051 (Frenchman River below Val Marie) to the 11AC041 (Frenchman River at the International Boundary) (see Appendix 2).

A third spreadsheet, S3, is used to compare values from the model with values from the conventional technique. The results from the comparison spreadsheet along with irrigation diversion (conventional technique, see Appendix 3) and precipitation are shown in Table 4 and Figure 5.

1.1.8 Adjustments to historical net depletion values

In the 1960s the conventional technique used to calculate net depletion for the Val Marie area was not the same as the present technique. Channel losses were calculated as a constant plus a varying percentage, and irrigation return flows were calculated as a different percentage of total irrigation diversion (Collier, 1960, p.4-6). Also the Imperial system of units was used in these years. Adjustments for these factors is made by taking the period volumes from the WRB Basin Files, converting cfs/days to dam^3, and entering the resultant volumes in spreadsheet S4 (see Appendix 3). S4 is the Val Marie portion of a spreadsheet presently used to determine international apportionment. The adjusted conventional values for 1966, 1968 and 1969 are shown in Table 4 and Figure 5.

1.1.9 Precipitation

An investigation of Atmospheric Environment Service records for Val Marie weather station, located directly in the ungauged portion of Val Marie area (AES, 1981 p.123) was done. Table 4 also contains the total rainfall recorded in millimetres for 11AC025 (Denniel Creek) periods. No record was found for 1966.

TABLE 4

VAL MARIE AREA NET DEPLETION AND IRRIGATION VOLUMES
(Cubic Decametres)

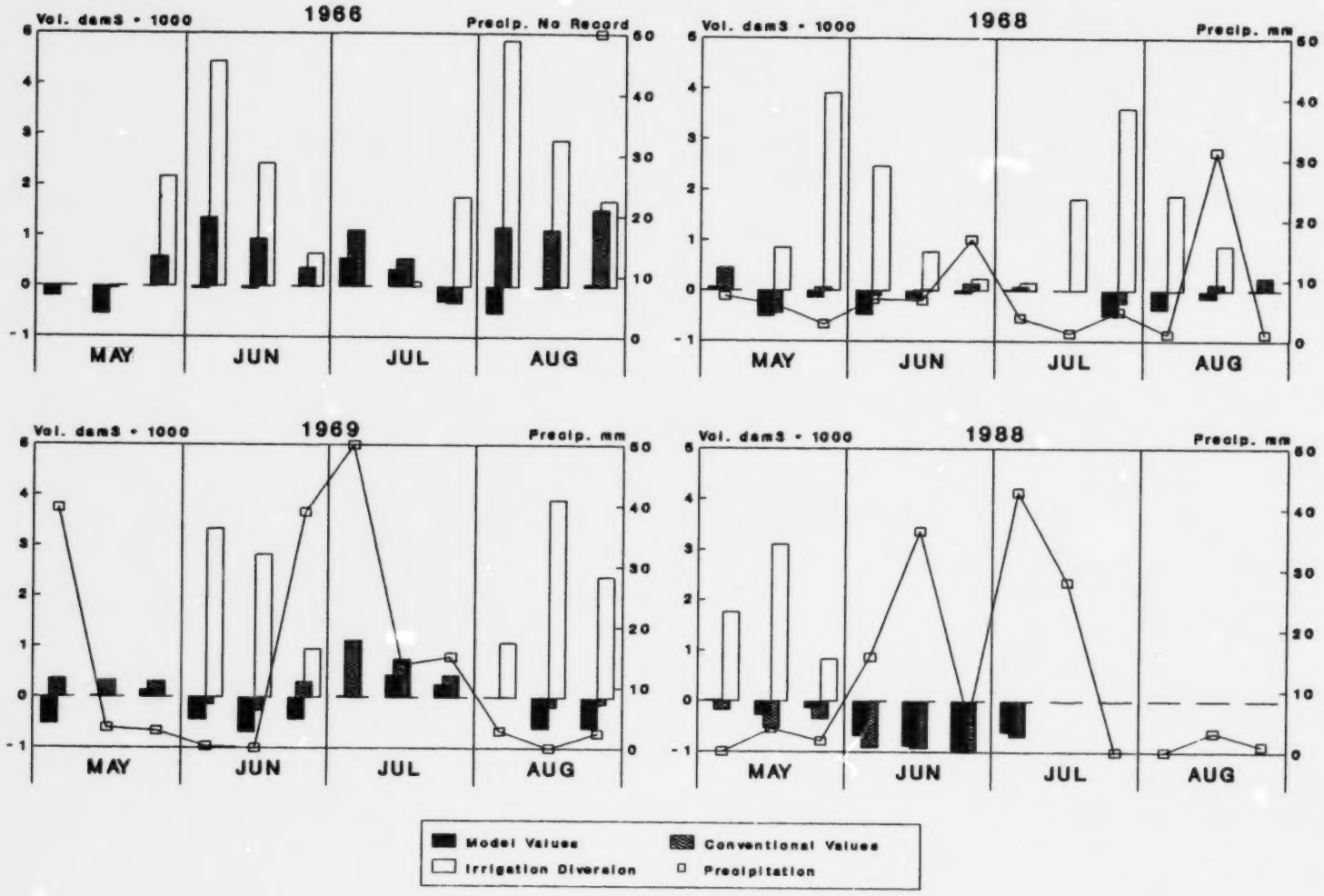
Year	Period Int. Boun.	Model Values	Conventional Values	Difference M-C	Irrigation Diversion	Precip. * (mm)
1966	May 1-10	-200	0	-200	0	NR
	May 11-20	-550	-38	-512	0	NR
	May 21-31	-5	587	-591	2168	NR
	Jun 1-10	-36	1356	-1392	4441	NR
	Jun 11-20	-39	941	-980	2425	NR
	Jun 21-30	0	378	-378	656	NR
	Jul 1-10	565	1110	-544	12	NR
	Jul 11-20	342	550	-207	93	NR
	Jul 21-31	-284	-321	37	1771	NR
	Aug 1-10	-520	1177	-1697	4854	NR
	Aug 11-20	-27	1130	-1157	2889	NR
	Aug 21-31	62	1530	-1468	1705	NR
		total-----	total-----	mean-----		
		-690	8401	-758		
1968	May 1-10	82	454	-372	5	7.4
	May 11-20	-509	-439	-69	847	6.1
	May 21-31	-132	70	-202	3915	2.8
	Jun 1-10	-468	-88	-380	2464	6.9
	Jun 11-20	-140	18	-158	771	6.7
	Jun 21-30	-52	134	-186	232	16.8
	Jul 1-10	27	80	-53	154	3.8
	Jul 11-20	0	1	-1	1823	1.3
	Jul 21-31	-499	-244	-254	3614	4.8
	Aug 1-10	-367	-5	-362	1884	1.1
	Aug 11-20	-140	133	-273	886	31.3
	Aug 21-31	23	265	-242	10	1.1
		total-----	total-----	mean-----		
		-2174	380	-213		
1969	May 1-10	-521	359	-879	0	39.5
	May 11-20	31	326	-295	0	3.3
	May 21-31	145	312	-167	0	2.8
	Jun 1-10	-436	-128	-308	3332	0.3
	Jun 11-20	-684	-254	-430	2831	0
	Jun 21-30	-426	308	-735	947	38.9
	Jul 1-10	29	1118	-1089	0	52.3
	Jul 11-20	450	760	-311	0	13.7
	Jul 21-31	266	433	-167	0	15
	Aug 1-10	0	0	0	1081	2.8
	Aug 11-20	-602	-185	-417	3910	0
	Aug 21-31	-600	-119	-480	2400	2.5
		total-----	total-----	mean-----		
		-2348	2931	-440		
1988	May 1-10	30	-175	205	1752	0
	May 11-20	-263	-518	255	3102	3.8
	May 21-31	-124	-347	223	835	1.8
	Jun 1-10	-668	-911	243	10	15.6
	Jun 11-20	-879	-915	36	0	36.4
	Jun 21-30	-962	-1099	137	0	5.4
	Jul 1-10	-602	-691	89	0	42.8
	Jul 11-20	0	-4	4	0	28
	Jul 21-31	0	-8	8	0	0
	Aug 1-10	0	0	0	0	0
	Aug 11-20	0	0	0	0	3.2
	Aug 21-31	0	0	0	0	1
		total-----	total-----	mean-----		
		-3467	-4668	100		

*Val Marie Weather Station (AES)
NR: No Record available

FIGURE 5

NET DEPLETION, IRRIGATION AND PRECIPITATION

VAL MARIE AREA



1.1.10 Results

For the years 1966, 1968 and 1969 the model calculates lesser net depletion values than the conventional technique. In 1988 the model calculates greater net depletion values than the conventional technique. The relatively close agreement in 1988 is encouraging. Larger differences in 1988 occur when irrigation diversion is large (see Table 4 and Figure 5). These differences may be caused by error in estimating irrigation return flow or error in estimating reservoir evaporation when using the conventional technique.

Agreement between model and conventional values is limited at best for the years 1966, 1968 and 1969, however, this small agreement is further encouragement. Again, the larger differences occur during periods of large irrigation diversion with some exceptions. Also, 1960s differences may be a result of the fair to poor quality of the historical record collected at 11AC051 (Yee, 1986).

Estimates of local inflow are generally not significant volumes, however in the first period of May 1969 the estimate is quite a large volume, 1 070 dam^3, 17 percent of the volume for Frenchman River below Val Marie (see Appendix 2). If this estimated local inflow is not used for May 1969 the result is a negative net depletion nearly three times greater for Val Marie area (-1484 dam^3 instead of -521 dam^3). This is evidence that local inflow can be an important contribution to inflow.

1.1.11 Sources of error

If flows at Frenchman River at 50 Mile, Denniel Creek, Denniel Creek East Tributary and Frenchman River below Val Marie are accurately recorded, then errors when using the inflow/outflow model have only two possible sources: calculation of channel loss or estimation of local inflow.

Channel losses are considered to be reasonably accurate (Cuthbert and Langley, 1974 p.31).

Some disagreements between model and conventional values occur when substantial rainfall is recorded. During periods with rain, irrigation return flow is likely larger than the conventional estimate. Also, there are periods of large disagreement and little rainfall. When local inflow is a negligible volume, the model must be correct. Most large differences between the model and the conventional technique are within the range of irrigation volumes.

2.0 CONCLUSIONS

The inflow/outflow model shows promise and the results obtained for 1988 are encouraging.

Estimation of local inflow is the only difficulty to be overcome.

3.0 RECOMMENDATIONS

Data collection for and testing of the model should continue.

Data collection should be done as early as possible in the spring since the larger volumes of the spring season would reduce the magnitude of error. The two techniques could be compared in a quite different set of conditions since large positive net depletions occur during spring in the form of reservoir storage with little irrigation,(the reverse of summer conditions, negative net depletion and large irrigation volumes). A comparison could be made of net depletions determined from reservoir elevation and from inflow/outflow method, with the objective of refining estimates of local inflow. Also, the inflow/outflow model could be tested for use during the entire apportionment season.

A study of the ungauged portion of the Val Marie area should be done to help refine estimation of local inflow. Contribution to inflow through the smaller tributaries by irrigation pumping of groundwater, natural springs, and precipitation should be examined.

4.0 SUGGESTIONS

Refinement of local inflow estimates may be possible by development of an equation containing precipitation data from Val Marie weather station and some measure of local soil conditions like moisture level and season. The form of the equation would be similar to this.

Local Inflow	=	Seasonal Constant	*	Soil Moisture Level	*	Precipitation

The seasonal constant would have a changing value derived empirically.

Perhaps the Val Marie area can be broken into two blackboxes, one for each reservoir (Huff Lake and Newton Lake) and it's associated canals. This would require establishment of a flow station somewhere near the top of Newton Lake (Yee, 1989).

5.0 REFERENCES

Atmospheric Environment Service Environment Canada, CLIMATOLOGICAL STATION DATA CATALOGUE PRAIRIE PROVINCES, Downsview, Ontario, 1981

Collier, E.P., A SUGGESTED NEW METHOD FOR THE APPORTIONMENT OF THE WATERS OF THE ST. MARY AND MILK RIVERS, Internal 36, Calgary, Alberta, 1960

Cuthbert, D.R. and E.R. Langley, FRENCHMAN RIVER HYDROGY STUDY, Internal 114 Volume 1, Ottawa, Ontario, 1974

Environment Canada, Hydrodata CD ROM, Denver, Colorado, 1988

Inland Waters Directorate Environment Canada, Surface Water Data Reference Index, Ottawa, Ontario, 1989

Johnson, B., Water Resources Branch Environment Canada Memo 5900/3-3-1, Regina, Saskatchewan, 10/06/1986

Martin F.R.J., Prairie Farm Rehabilitation Administration Hydrology Division Memo 928/7F5 928/8M21, Regina, Saskatchewan, 02/20/1985

Meid, P.O. and D.A. Schoenfield, P.F.R.A. HYDROLOGY REPORT #104 ADDENDUM No. 4 THE DETERMINATION OF GROSS AND EFFECTIVE DRAINAGE AREAS IN THE PRAIRIE PROVINCES, Regina, Saskatchewan, 1989

United States Geological Survey and Water Resources Branch Environment Canada, PROCEDURES FOR THE DIVISION OF THE ST. MARY AND MILK RIVERS, USGS and WRB, 1981

Yee, B., Personal Communication, Regina, Saskatchewan, June 1989

Yee, B., Water Resources Branch Environment Canada Memo 5900/3-3-1, Regina, Saskatchewan, 10/06/1986

Appendix 1

Spreadsheet 1
DAILY FLOWS AND PERIOD VOLUMES 1969

DAILY FLOWS (m3/s) AND PERIOD VOLUMES (dam3) for 1969

11AC023

1969	APR	MAY	JUN	JUL	AUG
1		4.87	0.648	0.835	0.745
2		4.02	0.646	0.733	0.68
3		3.94	0.614	0.875	0.558
4		4.56	0.561	1.08	0.481
5		4.16	0.513	1.31	0.467
6		4.02	0.504	0.818	0.425
7		3.99	0.484	1.1	0.379
8		3.94	0.476	1.31	0.34
9		3.17	0.464	2.38	0.297
10		2.77	0.453	1.93	0.261
11		2.58	0.447	1.49	0.227
12		2.37	0.459	1.78	0.201
13		2.09	0.436	1.37	0.15
14		2.04	0.422	1.16	0.119
15		2.05	0.399	1.18	0.099
16		2.01	0.391	1.04	0.091
17		2	0.399	0.869	0.079
18		1.92	0.394	0.748	0.093
19		1.91	0.382	0.646	0.108
20		1.88	0.419	0.595	0.11
21		1.7	0.453	1.81	0.119
22		1.48	0.464	1.14	0.13
23		1.45	0.453	1.48	0.139
24		1.46	0.484	0.963	0.159
25		1.4	0.569	0.643	0.19
26		1.33	0.646	1.05	0.221
27	3.7	1.21	0.762	1.18	0.207
28	3.8	1.03	0.991	1.1	0.198
29	3.9	0.895	1.04	0.886	0.19
30	3.99	0.796	1.02	0.796	0.156
31		0.705		0.759	0.139
Total	15.39	73.746	16.393	35.056	7.758

Period 11AC023	Volume dam3
APR 27-MAY 6	3538.94
MAY 7-16	2333.66
MAY 17-27	1532.73
MAY 28-JUN 6	597.196
JUN 7-16	382.838
JUN 17-26	402.883
JUN 27-JUL 6	817.689
JUL 7-16	1273.53
JUL 17-27	961.113
JUL 28-AUG 6	595.900
AUG 7-16	186.969
AUG 17-27	134.352

11AC025

1969	APR	MAY	JUN	JUL	AUG
1		3.51	0.011	0.01	0
2		4.28	0.01	0.009	0
3		1.89	0.008	0.012	0
4		1.28	0.007	0.013	0
5		0.861	0.007	0.013	0
6		0.43	0.005	0.011	0
7		0.227	0.003	0.011	0
8		0.153	0.003	0.012	0
9		0.113	0.003	0.013	0
10		0.093	0.003	0.011	0
11		0.082	0.003	0.009	0
12		0.074	0.002	0.008	0
13		0.065	0.003	0.007	0
14		0.057	0.003	0.007	0
15		0.054	0.002	0.006	0
16		0.051	0.002	0.006	0
17		0.048	0.002	0.005	0
18		0.045	0.001	0.006	0
19		0.042	0.001	0.006	0
20		0.042	0.001	0.004	0
21		0.04	0.003	0.003	0
22		0.037	0.005	0.003	0
23		0.034	0.007	0.002	0
24		0.031	0.007	0.001	0
25		0.028	0.008	0	0
26		0.025	0.01	0	0
27		0.022	0.01	0	0
28	0.736	0.019	0.01	0	0
29	0.394	0.017	0.011	0	0
30	0.343	0.016	0.01	0	0
31		0.013		0	0
Total	1.473	13.679	0.161	0.188	0

Period 11AC025	Volume dam3
APR 28-MAY 7	1205.36
MAY 8-17	68.256
MAY 18-28	31.536
MAY 29-JUN 7	8.3808
JUN 8-17	2.2464
JUN 18-27	4.5792
JUN 28-JUL 7	9.504
JUL 8-17	7.2576
JUL 18-28	2.16
JUL 29-AUG 7	0
AUG 8-17	0
AUG 18-28	0

11AC051

1969	APR	MAY	JUN	JUL	AUG
1		2.66	1.02	0.626	0.382
2		6.48	1.32	0.578	0.385
3		9.49	1.1	0.804	0.391
4		10.9	1.39	0.634	0.416
5		11.1	1.45	0.643	0.64
6		10.8	1.45	0.64	0.648
7		9.85	1.47	0.646	0.881
8		8.04	1.52	0.677	0.954
9		5.45	1.66	0.674	1.14
10		2.55	1.57	0.6	1.05
11		2.44	1.44	0.558	1.06
12		2.36	1.39	0.541	1.05
13		2.34	1.3	0.524	1.01
14		2.32	1.36	0.515	0.974
15		2.31	1.33	0.524	0.943
16		2.28	1.28	0.501	0.988
17		2.28	1.12	0.49	1
18		2.26	0.963	0.496	1.11
19		2.26	0.895	0.479	1.03
20		2.25	1.06	0.47	1.11
21		2.23	1.22	0.484	1.12
22		1.24	1.21	0.453	1.06
23		0.875	1.19	0.405	0.861
24		0.852	1.01	0.428	0.748
25		0.847	0.92	0.411	0.813
26		0.855	1.02	0.408	1.04
27		0.847	0.838	0.394	0.821
28		0.782	0.745	0.382	0.677
29	2.09	0.731	0.83	0.394	0.527
30	2.11	0.731	0.753	0.394	0.388
31		0.765		0.399	0.399
Total	4.2	109.17	35.824	16.172	25.616

Period 11AC051	Volume dam3
APR 29-MAY 8	6352.12
MAY 9-18	2124.57
MAY 19-29	1189.64
MAY 30-JUN 8	1055.46
JUN 9-18	1158.88
JUN 19-28	873.331
JUN 29-JUL 8	590.198
JUL 9-18	468.547
JUL 19-29	406.771
JUL 30-AUG 8	474.336
AUG 9-18	892.08
AUG 19-29	847.324

11AC073

1969	APR	MAY	JUN	JUL	AUG
1	0	0.872	0	0	0
2	0	1.064	0	0	0
3	0	0.467	0	0	0
4	0	0.314	0	0	0
5	0	0.209	0	0	0
6	0	0.102	0	0	0
7	0	0.051	0	0	0
8	0	0.032	0	0	0
9	0	0.022	0	0	0
10	0	0.017	0	0	0
11	0	0.015	0	0	0
12	0	0.013	0	0	0
13	0	0.01	0	0	0
14	0	0.008	0	0	0
15	0	0.008	0	0	0
16	0	0.007	0	0	0
17	0	0.006	0	0	0
18	0	0.005	0	0	0
19	0	0.005	0	0	0
20	0	0.005	0	0	0
21	0	0.004	0	0	0
22	0	0.003	0	0	0
23	0	0.002	0	0	0
24	0	0.002	0	0	0
25	0	0.001	0	0	0
26	0	0	0	0	0
27	0	0	0	0	0
28	0.178	0	0	0	0
29	0.093	0	0	0	0
30	0.08	0	0	0	0
31	0	0	0	0	0
Total	0.351	3.244	0	0	0

11AC073 Daily Flows Estimated

Period 11AC073	Volume dam3
APR 28-MAY 7	296.352
MAY 8-17	11.9232
MAY 18-28	2.3328
MAY 29-JUN 7	0
JUN 8-17	0
JUN 18-27	0
JUN 28-JUL 7	0
JUL 8-17	0
JUL 18-28	0
JUL 29-AUG 7	0
AUG 8-17	0
AUG 18-28	0

Appendix 2

Spreadsheet 2
INFLOW/OUTFLOW MODEL FOR VAL MARIE AREA

INFLOW/OUTFLOW MODEL FOR VAL MARIE AREA
(CUBIC DECAMETRES)

	PERIOD	1 MEASURED FLOW FRENCHMAN AT 50 MILE 11AC023 OBSERVED	2 CHANNEL LOSS TO 11AC051 COMPUTED	3 UNGAUGED LOCAL INFLOW 0.88844	PERIOD	4 MEASURED FLOW DENNIEL CREEK 11AC025 OBSERVED	5 FLOW EAST TRIBUTARY 11AC073	6 EXPECTED FLOW BELOW VAL MARIE 11AC051 1-2+3+4+5	PERIOD	7 MEASURED FLOW BELOW VAL MARIE 11AC051 OBSERVED	8 GROSS DEPLETION VAL MARIE 8-7	9 CHANNEL LOSS TO INTERNTNL BOUNDARY COMPUTED	10 NET DEPLETION VAL MARIE 8-9
1966	APR 27-MAY 6	2285	261	8	APR 28-MAY 7	9	0	2040	APR 29-MAY 8	2311	-271	-71	-200
	MAY 7-16	2251	258	8	MAY 8-17	8	0	2009	MAY 9-18	2669	-660	-110	-550
	MAY 17-27	1162	152	7	MAY 18-28	8	0	1025	MAY 19-29	1084	-59	-55	-5
	MAY 28-JUN 6	743	149	6	MAY 29-JUN 7	6	0	606	MAY 30-JUN 8	698	-92	-56	-36
	JUN 7-16	631	132	5	JUN 8-17	6	0	511	JUN 9-18	607	-96	-57	-39
	JUN 17-26	716	145	8	JUN 18-27	9	0	587	JUN 19-28	554	33	33	0
	JUN 27-JUL 6	1138	213	8	JUN 28-JUL 7	8	0	941	JUN 29-JUL 8	213	722	157	565
	JUL 7-16	840	165	3	JUL 8-17	3	0	682	JUL 9-18	225	457	114	342
	JUL 17-27	526	118	0	JUL 18-28	0	0	408	JUL 19-29	800	-392	-108	-284
	JUL 28-AUG 6	337	84	0	JUL 29-AUG 7	0	0	252	JUL 30-AUG 8	920	-668	-148	-520
	AUG 7-16	322	82	0	AUG 8-17	0	0	240	AUG 9-18	321	-82	-54	-27
	AUG 17-27	567	124	3	AUG 18-28	3	0	449	AUG 19-29	321	128	66	62
1968	APR 27-MAY 6	1976	230	5	APR 28-MAY 7	6	0	1757	APR 29-MAY 8	1617	140	58	82
	MAY 7-16	1207	153	5	MAY 8-17	6	0	1064	MAY 9-18	1679	-614	-106	-509
	MAY 17-27	922	128	3	MAY 18-28	4	0	800	MAY 19-29	1001	-201	-69	-132
	MAY 28-JUN 6	476	107	2	MAY 29-JUN 7	2	0	373	MAY 30-JUN 8	979	-606	-138	-468
	JUN 7-16	373	90	3	JUN 8-17	3	0	290	JUN 9-18	505	-216	-76	-140
	JUN 17-26	299	78	2	JUN 18-27	2	0	225	JUN 19-28	336	-112	-59	-52
	JUN 27-JUL 6	310	80	2	JUN 28-JUL 7	2	0	234	JUN 29-JUL 8	152	82	54	27
	JUL 7-16	440	101	0	JUL 8-17	0	0	339	JUL 9-18	360	-22	-22	0
	JUL 17-27	140	56	0	JUL 18-28	0	0	84	JUL 19-29	732	-648	-149	-499
	JUL 28-AUG 6	108	48	0	JUL 29-AUG 7	0	0	60	JUL 30-AUG 8	546	-486	-119	-367
	AUG 7-16	121	50	0	AUG 8-17	0	0	71	AUG 9-18	287	-216	-76	-140
	AUG 17-27	300	82	0	AUG 18-28	0	0	218	AUG 19-29	136	82	59	23
1969	APR 27-MAY 6	3539	387	1070	APR 28-MAY 7	1305	296	5724	APR 29-MAY 8	6252	-628	-107	-521
	MAY 7-16	2334	266	61	MAY 8-17	68	12	2208	MAY 9-18	2125	84	53	31
	MAY 17-27	1533	189	28	MAY 18-28	32	2	1405	MAY 19-29	1190	216	70	145
	MAY 28-JUN 6	597	126	7	MAY 29-JUN 7	8	0	487	MAY 30-JUN 8	1055	-569	-132	-436
	JUN 7-16	383	92	2	JUN 8-17	2	0	295	JUN 9-18	1159	-864	-180	-684
	JUN 17-26	403	95	4	JUN 18-27	5	0	316	JUN 19-28	873	-557	-130	-426
	JUN 27-JUL 6	818	161	8	JUN 28-JUL 7	10	0	674	JUN 29-JUL 8	590	84	55	29
	JUL 7-16	1274	234	6	JUL 8-17	7	0	1053	JUL 9-18	469	584	135	450
	JUL 17-27	961	187	2	JUL 18-28	2	0	778	JUL 19-29	407	371	105	266
	JUL 28-AUG 6	596	126	0	JUL 29-AUG 7	0	0	470	JUL 30-AUG 8	474	-4	-4	0
	AUG 7-16	187	60	0	AUG 8-17	0	0	126	AUG 9-18	892	-766	-164	-602
	AUG 17-27	134	55	0	AUG 18-28	0	0	79	AUG 19-29	847	-768	-168	-600
1988	APR 27-MAY 6	363	69	2	APR 28-MAY 7	2	0	299	APR 29-MAY 8	216	83	53	30
	MAY 7-16	221	55	3	MAY 8-17	3	0	172	MAY 9-18	513	-341	-78	-263
	MAY 17-27	256	62	0	MAY 18-28	0	0	194	MAY 19-29	387	-193	-68	-124
	MAY 28-JUN 6	112	48	0	MAY 29-JUN 7	0	0	64	MAY 30-JUN 8	908	-844	-176	-668
	JUN 7-16	77	43	0	JUN 8-17	0	0	34	JUN 9-18	1129	-1095	-217	-879
	JUN 17-26	44	38	0	JUN 18-27	0	0	6	JUN 19-28	1201	-1195	-232	-962
	JUN 27-JUL 6	4	4	0	JUN 28-JUL 7	0	0	0	JUN 29-JUL 8	766	-766	-164	-602
	JUL 7-16	9	9	0	JUL 8-17	0	0	0	JUL 9-18	1	-1	-1	0
	JUL 17-27	0	0	0	JUL 18-28	0	0	0	JUL 19-29	0	0	0	0
	JUL 28-AUG 6	0	0	0	JUL 29-AUG 7	0	0	0	JUL 30-AUG 8	0	0	0	0
	AUG 7-16	0	0	0	AUG 8-17	0	0	0	AUG 9-18	0	0	0	0
	AUG 17-27	0	0	0	AUG 18-28	0	0	0	AUG 19-29	0	0	0	0

Appendix 3

Spreadsheet 4
CORRECTIONS OF HISTORICAL DATA 1969

1969 CORRECTIONS OF HISTORICAL DATA — VAL MARIE AREA (CUBIC DECAMETRES)

	VAL MARIE AREA K=4.92			PERIOD VAL MARIE AREA	16 HUFF LAKE		17	18	19 NEWTON LAKE		20	21	22
	DAYS	KADAYS	P		STORED + RELEASED -		EVAPORATION	DEPLETION	STORED + RELEASED -		EVAPORATION	DEPLETION	TOTAL CHANGE IN RESERVOIR CONTENTS
					cfs/day	OBSERVED	cfs/day	COMPUTED	16+17	cfs/day	OBSERVED	cfs/day	COMPUTED	19+20	18+21
MAR	10	49.2	0.04	FEB 26-MAR 7	18	44	0	0	44	-7	-17	0	0	-17	27
	10	49.2	0.04	MAR 8-17	54	132	0	0	132	7	17	0	0	17	149
	11	54.12	0.04	MAR 18-28	141	345	0	0	345	17	42	0	0	42	387
APR	10	49.2	0.06	MAR 29-APR 7	1251	3061	5	12	3073	1567	3834	8	20	3853	6926
	10	49.2	0.06	APR 8-17	-322	-788	21	51	-736	1921	4700	56	137	4837	4101
	10	49.2	0.06	APR 18-27	158	387	41	100	487	0	0	105	257	257	744
MAY	10	49.2	0.1	APR 28-MAY 7	33	81	24	59	139	59	144	67	164	308	448
	10	49.2	0.1	MAY 8-17	-63	-154	42	103	-51	75	183	114	279	462	411
	11	54.12	0.1	MAY 18-28	-56	-137	55	135	-2	15	37	150	367	404	401
JUN	10	49.2	0.16	MAY 29-JUN 7	-453	-1108	56	137	-971	-857	-2097	150	367	-1730	-2701
	10	49.2	0.16	JUN 8-17	-372	-910	44	108	-802	-795	-1945	112	274	-1671	-2474
	10	49.2	0.16	JUN 18-27	-26	-64	18	44	-20	-155	-379	43	105	-274	-294
JUL	10	49.2	0.16	JUN 28-JUL 7	336	822	22	54	876	155	379	51	125	504	1380
	10	49.2	0.16	JUL 8-17	357	873	39	95	969	-89	-218	83	203	-15	954
	11	54.12	0.16	JUL 18-28	158	387	49	120	506	-72	-176	98	240	64	570
AUG	10	49.2	0.16	JUL 29-AUG 7	-162	-396	58	142	-254	-324	-793	114	279	-514	-768
	10	49.2	0.16	AUG 8-17	-716	-1752	48	117	-1634	-733	-1793	92	225	-1568	-3203
	11	54.12	0.16	AUG 18-28	-362	-886	43	105	-780	-588	-1439	91	223	-1216	-1996
SEP	10	49.2	0.1	AUG 29-SEP 7	-120	-294	24	59	-235	-136	-333	58	142	-191	-426
	10	49.2	0.1	SEP 8-17	13	32	22	54	86	-130	-318	52	127	-191	-105
	10	49.2	0.1	SEP 18-27	50	122	13	32	154	-34	-83	29	71	-12	142
OCT	10	49.2	0.06	SEP 28-OCT 7	85	208	10	24	232	-46	-113	19	46	-66	166
	10	49.2	0.06	OCT 8-17	336	822	8	20	842	-72	-176	13	32	-144	697
	11	54.12	0.06	OCT 18-28	252	617	12	29	646	-73	-179	16	39	-139	506
				TOTAL	590	1443	654	1600	3044	-295	-722	1521	3721	3000	6043

1969 CORRECTIONS OF HISTORICAL DATA

VAL MARIE AREA
(CUBIC DECAMETRES)

PERIOD VAL MARIE AREA	27 HUFF LAKE GRAVITY CANAL cfs/day	27 HUFF LAKE GRAVITY CANAL MEASURED	24 HUFF LAKE PUMPING CANAL cfs/day	24 HUFF LAKE PUMPING CANAL MEASURED	25 NEWTON MAIN CANAL cfs/day	25 NEWTON MAIN CANAL MEASURED	26 TOTAL CANAL DIVERSION 23+24+25	27 RETURN FLOW COMPUTED	28 GROSS DEPLETION VAL MARIE 22+26-27	29 CHANNEL LOSS TO INTERNATIONAL BOUNDARY COMPUTED	30 NET DEPLETION VAL MARIE 28-29
FEB 26-MAR 7	0	0	0	0	0	0	0	0	27	27	0
MAR 8-17	0	0	0	0	0	0	0	0	149	53	96
MAR 18-28	0	0	0	0	0	0	0	0	387	67	320
MAR 29-APR 7	0	0	0	0	0	0	0	0	6926	462	6464
APR 8-17	0	0	0	0	0	0	0	0	4101	292	3809
APR 18-27	0	0	0	0	0	0	0	0	744	91	653
APR 28-MAY 7	0	0	0	0	0	0	0	0	448	89	359
MAY 8-17	0	0	0	0	0	0	0	0	411	85	326
MAY 18-28	0	0	0	0	0	0	0	0	401	89	312
MAY 29-JUN 7	352	861	252	617	758	1855	3332	833	-202	-74	-128
JUN 8-17	165	404	281	687	711	1740	2831	708	-351	-97	-254
JUN 18-27	0	0	166	406	221	541	947	237	416	108	308
JUN 28-JUL 7	0	0	0	0	0	0	0	0	1380	262	1118
JUL 8-17	0	0	0	0	0	0	0	0	954	194	760
JUL 18-28	0	0	0	0	0	0	0	0	570	137	433
JUL 29-AUG 7	82	201	52	127	308	754	1081	270	43	43	0
AUG 8-17	430	1052	271	663	897	2195	3910	977	-270	-85	-185
AUG 18-28	106	259	270	661	605	1480	2400	600	-196	-77	-119
AUG 29-SEP 7	0	0	124	303	99	242	546	136	-16	-16	0
SEP 8-17	0	0	0	0	65	159	159	40	14	14	0
SEP 18-27	0	0	0	0	0	0	0	0	142	58	84
SEP 28-OCT 7	0	0	0	0	0	0	0	0	166	56	110
OCT 8-17	0	0	0	0	0	0	0	0	697	88	609
OCT 18-28	0	0	4	10	0	0	10	2	514	82	432
TOTAL	1135	2777	1420	3474	3664	8964	15215	3803	17456	1948	15508

Appendix 4

ESTIMATED DAILY FLOWS FOR
11AC023 FRENCHMAN RIVER AT 50 MILE 1969
AND 11AC025 DENNIEL CREEK 1966

WATER SURVEY OF CANADA
OCT 01 1988 PAGE 9672
REGINA, SASK.

FRENCHMAN RIVER AT 50-MILE

STATION NO. 11AC023

DAILY DISCHARGE IN CUBIC METRES PER SECOND FOR 1969

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1	---	---	---	---	4.87	0.648	0.835	0.745	0.130	0.193	1.04	---	1
2	---	---	---	---	4.02	0.646	0.733	0.680	0.127	0.193	0.872	---	2
3	---	---	---	---	3.94	0.614	0.875	0.558	0.116	0.272	0.799	---	3
4	---	---	---	---	4.56	0.561	1.08	0.481	0.102	0.311	0.827	---	4
5	---	---	---	---	4.16	0.513	1.31	0.467A	0.139	0.278	---	---	5
6	---	---	---	---	4.02	0.504	0.818	0.425E	0.195	0.269	---	---	6
7	---	---	---	---	3.99	0.484	1.10	0.379E	0.210	0.578	---	---	7
8	---	---	---	---	3.94	0.476	1.31	0.340E	0.187	0.719	---	---	8
9	---	---	---	---	3.17	0.464	2.38	0.297E	0.161	0.818	---	---	9
10	---	---	---	---	2.77	0.453	1.93	0.261E	0.147	0.790	---	---	10
11	---	---	---	---	2.58	0.447	1.49	0.227E	0.133	1.20	---	---	11
12	---	---	---	---	2.37	0.459	1.78	0.201E	0.130	1.44	---	---	12
13	---	---	---	---	2.09	0.436	1.37	0.150E	0.125	1.33	---	---	13
14	---	---	---	---	2.04	0.422	1.16	0.119E	0.119	1.15	---	---	14
15	---	---	---	---	2.05	0.399	1.18	0.099E	0.122	1.04	---	---	15
16	---	---	---	---	2.01	0.391	1.04	0.091E	0.122	1.00	---	---	16
17	---	---	---	---	2.00	0.399	0.869	0.079E	0.127	0.954	---	---	17
18	---	---	---	---	1.92	0.394	0.748	0.093E	0.122	0.923	---	---	18
19	---	---	---	---	1.91	0.382	0.646	0.108E	0.127	0.906	---	---	19
20	---	---	---	---	1.88	0.419	0.595	0.110E	0.136	0.937	---	---	20
21	---	---	---	---	1.70	0.453	1.81	0.119E	0.198	0.796	---	---	21
22	---	---	---	---	1.48	0.464	1.14	0.130A	0.193	0.765	---	---	22
23	---	---	---	---	1.45	0.453	1.48	0.139	0.198	0.742	---	---	23
24	---	---	---	---	1.46	0.484	0.963	0.159	0.201	0.759	---	---	24
25	---	---	---	---	1.40	0.569	0.643	0.190	0.207	0.773	---	---	25
26	---	---	---	---	1.33	0.646	1.05	0.221	0.224	0.773B	---	---	26
27	---	---	---	---	1.21	0.762	1.18	0.207	0.232	0.770B	---	---	27
28	---	---	---	3.7	1.03	0.991	1.10	0.198	0.229	0.770B	---	---	28
29	---		---	3.8	0.895	1.04	0.886	0.190	0.215	0.767B	---	---	29
30	---		---	3.9	0.796	1.02	0.796	0.156	0.210	0.765B	---	---	30
31	---		---		0.705		0.759	0.139		0.765		---	31
TOTAL	---	---	---	3.99	73.746	16.393	35.056	7.758	4.884	23.746	---	---	TOTAL
MEAN	---	---	---	---	2.38	0.546	1.13	0.250	0.163	0.766	---	---	MEAN
MAX	---	---	---	---	4.87	1.04	2.38	0.745	0.232	1.44	---	---	MAX
MIN	---	---	---	---	0.70	0.382	0.595	0.079	0.102	0.193	---	---	MIN

DISCHARGES IN CUBIC METRES PER SECOND

SUMMARY FOR THE MONTHS MAR TO OCT

MONTHLY TOTAL DISCHARGE IN CUBIC DECAMETRES

JAN	---	JUL	3 030
FEB	---	AUG	670
MAR	---	SEP	422
APR	---	OCT	2 050
MAY	6 370	NOV	---
JUN	1 420	DEC	---

MAXIMUM INSTANTANEOUS,
5.27 AT 07:27 MST ON MAY 1

A - MANUAL GAUGE
B - ICE CONDITIONS
E - ESTIMATED

WATER SURVEY OF CANADA
OCT 01 1988 PAGE 9700
REGINA, SASK.

DENNIEL CREEK NEAR VAL MARIE

STATION NO. 11AC025

DAILY DISCHARGE IN CUBIC METRES PER SECOND FOR 1966

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1	---	---	---	---	---	0.006	0.008	0	0	0	0.006	---	1
2	---	---	---	---	---	0.008	0.008	0	0	0	0.006	---	2
3	---	---	---	---	---	0.008	0.011	0	0	0	0.006	---	3
4	---	---	---	---	0.01	0.008	0.014	0	0	0	---	---	4
5	---	---	---	---	---	0.011	0.011	0	0	0	---	---	5
6	---	---	---	---	---	0.008	0.011	0	0	0.003	---	---	6
7	---	---	---	---	---	0.008	0.008	0	0	0.003	---	---	7
8	---	---	---	---	---	0.008	0.006	0	0	0	---	---	8
9	---	---	---	---	0.01	0.008	0.006	0	0	0	---	---	9
10	---	---	---	---	0.008	0.006	0.003	0	0	0	---	---	10
11	---	---	---	---	---	0.006	0.003	0	0	0	---	---	11
12	---	---	---	---	---	0.008	0	0	0	0	---	---	12
13	---	---	---	---	0.01	0.006	0	0	0	0.003	---	---	13
14	---	---	---	---	---	0.006	0.003	0	0	0.003	---	---	14
15	---	---	---	---	---	0.006	0.006	0	0	0.006	---	---	15
16	---	---	26.2	---	---	0.006	0.006	0	0	0.003	---	---	16
17	---	---	15.3	---	0.01	0.008	0.006	0	0	0.003	---	---	17
18	---	---	9.60	---	---	0.006	0.003	0	0	0.003	---	---	18
19	---	---	7.67	---	0.008	0.006	0	0	0	0.003	---	---	19
20	---	---	---	0.042	0.008	0.006	0	0	0	0.003	---	---	20
21	---	---	---	---	0.008	0.006	0	0	0	0.006	---	---	21
22	---	---	---	---	0.011	0.008	0	0.008	0	0.006	---	---	22
23	---	---	---	---	0.011	0.011	0	0.008	0	0.006	---	---	23
24	---	---	---	---	0.008	0.014	0	0.006	0	0.006	---	---	24
25	---	---	---	---	0.008	0.017	0	0.006	0	0.006	---	---	25
26	---	---	---	---	0.008	0.017	0	0.003	0	0.006	---	---	26
27	---	---	---	---	0.008	0.011	0	0.003	0	0.006	---	---	27
28	---	---	---	0.01	0.008	0.011	0	0.003	0	0.006	---	---	28
29	---		---	---	0.006	0.008	0	0.003	0	0.006	---	---	29
30	---		---	---	0.006	0.008	0	0	0	0.006	---	---	30
31	---		---		0.006		0	0		0.006		---	31
TOTAL	---	---	---	---	---	0.254	0.113	0.040	0	0.099	---	---	TOTAL
MEAN	---	---	---	---	---	0.008	0.004	0.001	0	0.003	---	---	MEAN
MAX	---	---	---	---	---	0.017	0.014	0.008	0	0.006	---	---	MAX
MIN	---	---	---	---	---	0.006	0	0	0	0	---	---	MIN

SUMMARY FOR THE MONTHS MAR TO OCT

DISCHARGES IN CUBIC METRES PER SECOND

MINIMUM DAILY, 0 ON JUL 12

MONTHLY TOTAL DISCHARGE IN CUBIC DECAMETRES

JAN	---	JUL	9.76
FEB	---	AUG	3.46
MAR	---	SEP	0
APR	---	OCT	8.55
MAY	---	NOV	---
JUN	21.9	DEC	---